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WADC TECHNICAL REPORT 52-137

SECURITY INFORMATION

LABORATORY TESTS OF INTERFERENCE BLANKER MX-(XA-115)/U WITH NAVIGATIONAL EQUIPMENTS

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COMMUNICATION AND NAVIGATION LABORATORY

JULY 1952

WRIGHT AIR DEVELOPMENT CENTER

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NOTICES

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LABORATORY TESTS OF INTERFERENCE BLANKER MX-(XA-115)/U WITH NAVIGATIONAL EQUIPMENTS

Raymond R. Holberger
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Communication and Navigation Laboratory

July 1952

RDO No. 112-28

Wright Air Development Center
Air Research and Development Command
United States Air Force
Wright-Patterson Air Force Base, Ohio

RESTRICTED

FOREWORD

The USAF activity discussed in this report has been performed by the Communication and Navigation Laboratory, Weapons Components Division, Wright Air Development Center, under RDO No. 112-28, entitled "Flight Research on Atmospheric Electricity and Development of Means to Reduce Precipitation Static." Tests were conducted by Mr. R. R. Holberger and Mr. H. M. Bartman, assisted by personnel from units responsible for the equipments under test. Project Engineer: Mr. H. C. Storck.

The tests were performed in the Laboratoy prior to construction of models to be used in flight tests.

ABSTRACT

Laboratory tests of Interference Blanker MX-(XA-115) in conjunction with Radar Sets AN/APN-9 and AN/APN-70 (Loran Equipment), with Converter CV-89/URA-8 and Teletypewriter TT-4/TG(XC-5), with a Hallicrafter's Radio Receiver Type SX-28, with a Stoddard NM 10A Radio Interference and Field Intensity Meter, and with an AN/PRM-1 Noise Meter are described and test data tabulated. Also, initial tests were conducted on the AN/ARN-6 Radio Compass. These tests were deemed necessary prior to the fabrication of three flight test models of the Interference Blanker MX-(XA-125)/U. The results point out a considerable alleviation of the effects of precipitation static upon received signals which would make possible communication and direction-finding fixes otherwise impossible. It is concluded that the development of the beam-deflection switching tube (described in WADC Technical Report No. 52-65) will be necessary in order to further lower the amplitude of switching transients so that radio receivers of higher orders of sensitivity may be employed; that already formulated anti-cross modulation plans and circuits will be needed to further advance the usefulness of the blanker; that flight tests of the blanker with the above equipments, and others, should be made; and that, according to laboratory tests, even the present model of the blanker would offer sufficient improvement to reception to merit consideration as an interim equipment.

The security classification of the title of this report is UNCLASSIFIED.

PUBLICATION REVIEW

This report has been reviewed and is approved.

FOR THE COMMANDING GENERAL:

for Robert E. Kester
CHARLES U. BROMBACH
Colonel, USAF
Chief, Comm and Nav Laboratory
Weapons Components Division

CONTENTS

ILLUSTRATIONS

SECTION I

INTRODUCTION

The reader is referred to the Bibliography for details regarding precipitation static, corona, blanker theory, and results. WADC Technical Report No. 52-65 especially is cited for such information. Low, medium, and high frequency receivers are especially vulnerable to precipitation static interference. These are represented mainly by communications equipment, Loran, FSK, and "On-Off" type teletype equipments, and the radio compass. Some modification is necessary for use of the blanker with the radio compass, and this work has not yet been completed. Nomenclature of Interference Blanker MX-(XA-125)/U has been assigned for three models of Interference Blanker MX-(XA-115)/U being fabricated for flight test use.

SECTION II

GENERAL FACTUAL DATA

In general, the tests were conducted as shown on Figures 1, 2, 9, and 14. Negative corona was drawn from the receiving antenna by means of the high voltage generator. Corona current (of the order of microamperes) was measured as one parameter; signal voltage to the receiving antenna as the other.

Communications Receivers

A Hallicrafter's Communication Radio Receiver Model SX-28, with an external meter to indicate second detector diode current, and Noise Meter AN/PRM-1 were used as representing medium and high frequency receivers and a Stoddard NM 10A Radio Interference and Field Intensity Meter was used to represent low frequency receivers. Signal intelligibility was determined by the arbitrary formula:

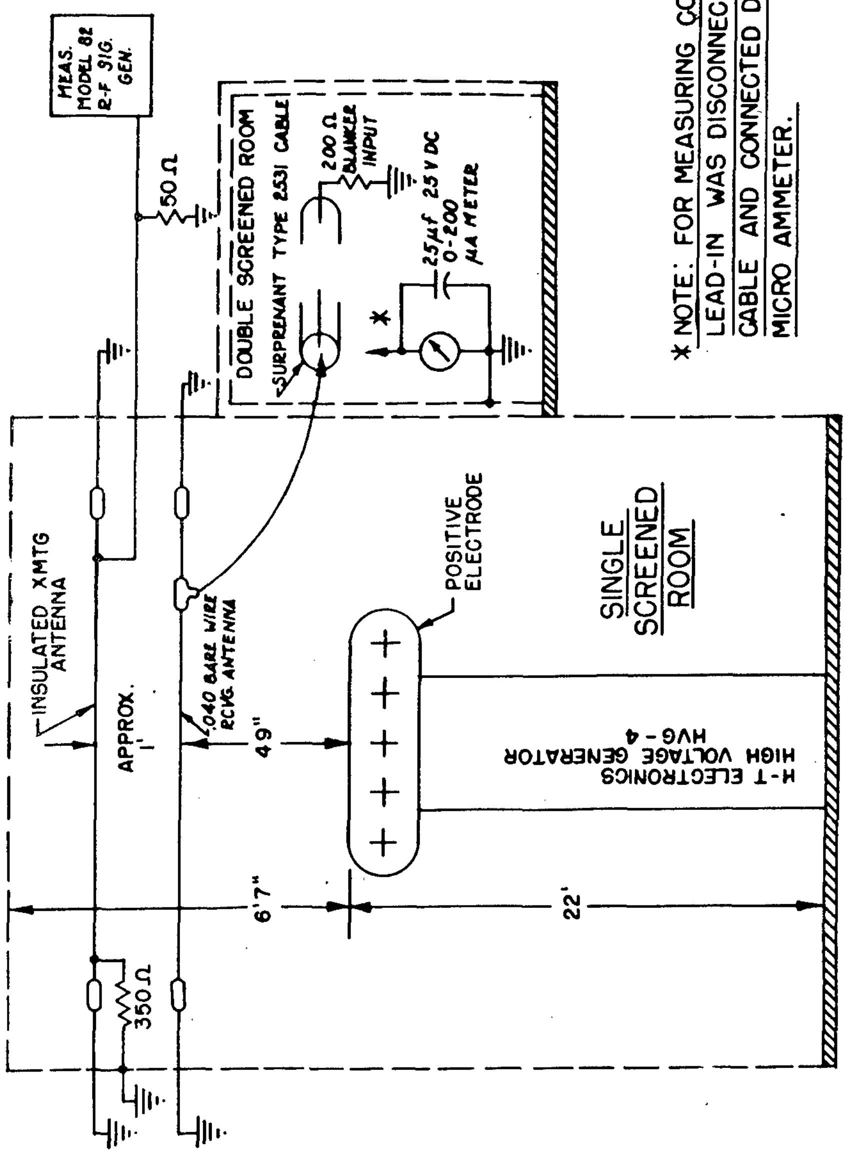
$$S + N = 2N$$

where S = Signal voltage at the receiving antenna.
N = Impulse Noise, i.e., noise due only to corona.

a. Noise Meter AN/PRM-1: The test set-up used is shown in Figure 2. The curves of Figures 3 and 4 show the improvement in minimum usable signal due to the Interference Blanker for several frequencies and corona currents. Figures 5 and 6 show the improvement in noise level obtained with the blanker.

The arbitrary formula used for determining minimum usable signal appears to be valid when receiving CW, but voice reception requires a slightly higher signal to noise ratio.

b. Hallicrafter's Receiver SX-28: Blanker operation on voice reception was tested using a standard broadcast signal. Radio Station WING (1410kc) with a signal voltage of about 50 microvolts on the screened room antenna (with a 200 ohm termination) was chosen for the voice tests. The corona current was increased until the signal, in the opinion of three people, could no longer be read. It was



* NOTE: FOR MEASURING CORONA, ANTENNA LEAD-IN WAS DISCONNECTED FROM THE CABLE AND CONNECTED DIRECTLY TO THE MICRO AMMETER.

FIG. 1 GENERAL LAYOUT OF HIGH VOLTAGE LABORATORY, ANTENNA TERMINATION AND CORONA CURRENT MEASURING SYSTEM.

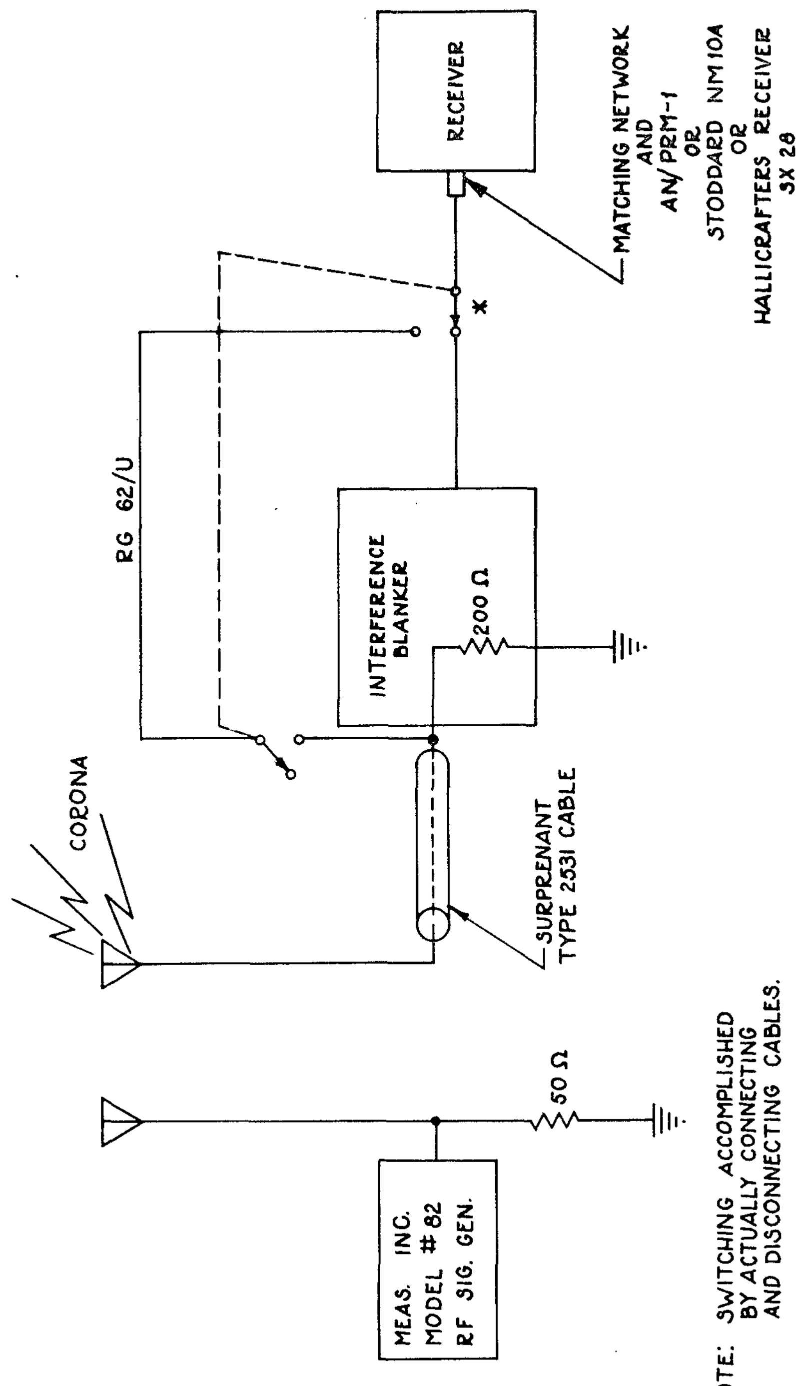
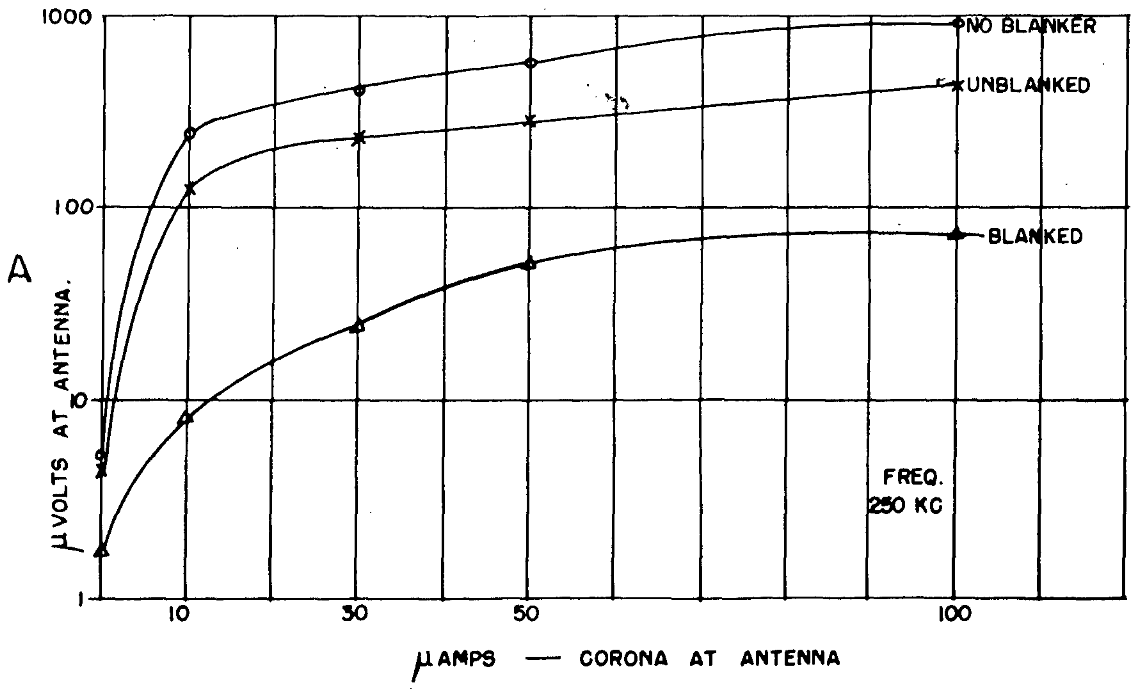


FIGURE 2 DIAGRAM FOR BLANKER PERFORMANCE TEST SET-UP.



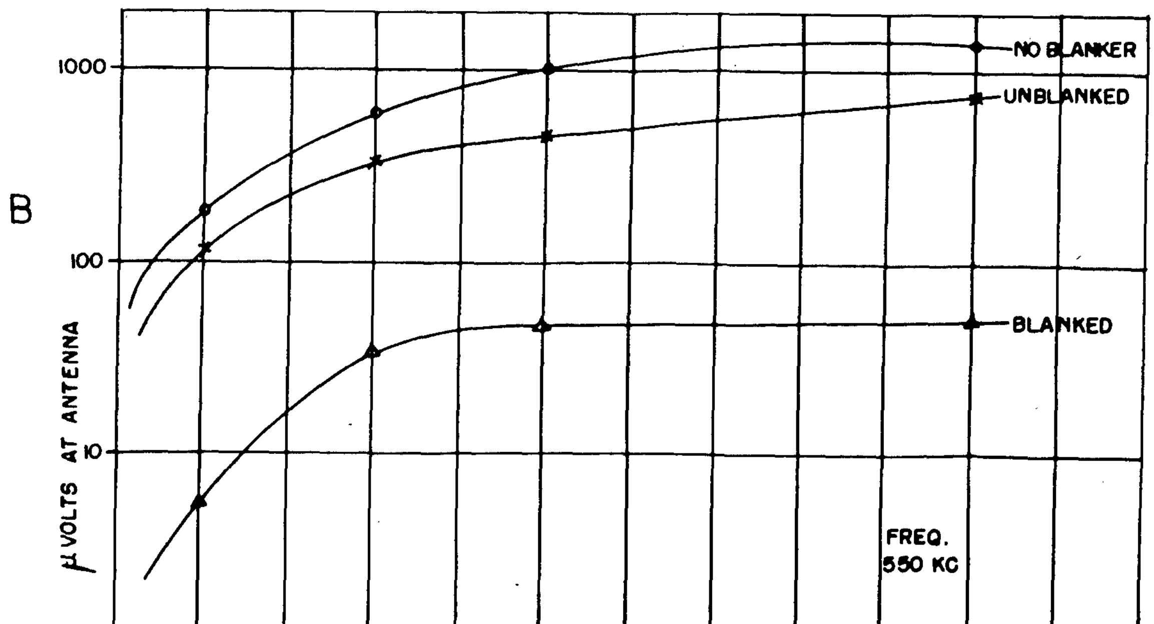


FIG. 3 MIN. R F SIGNAL VS CORONA CURRENT

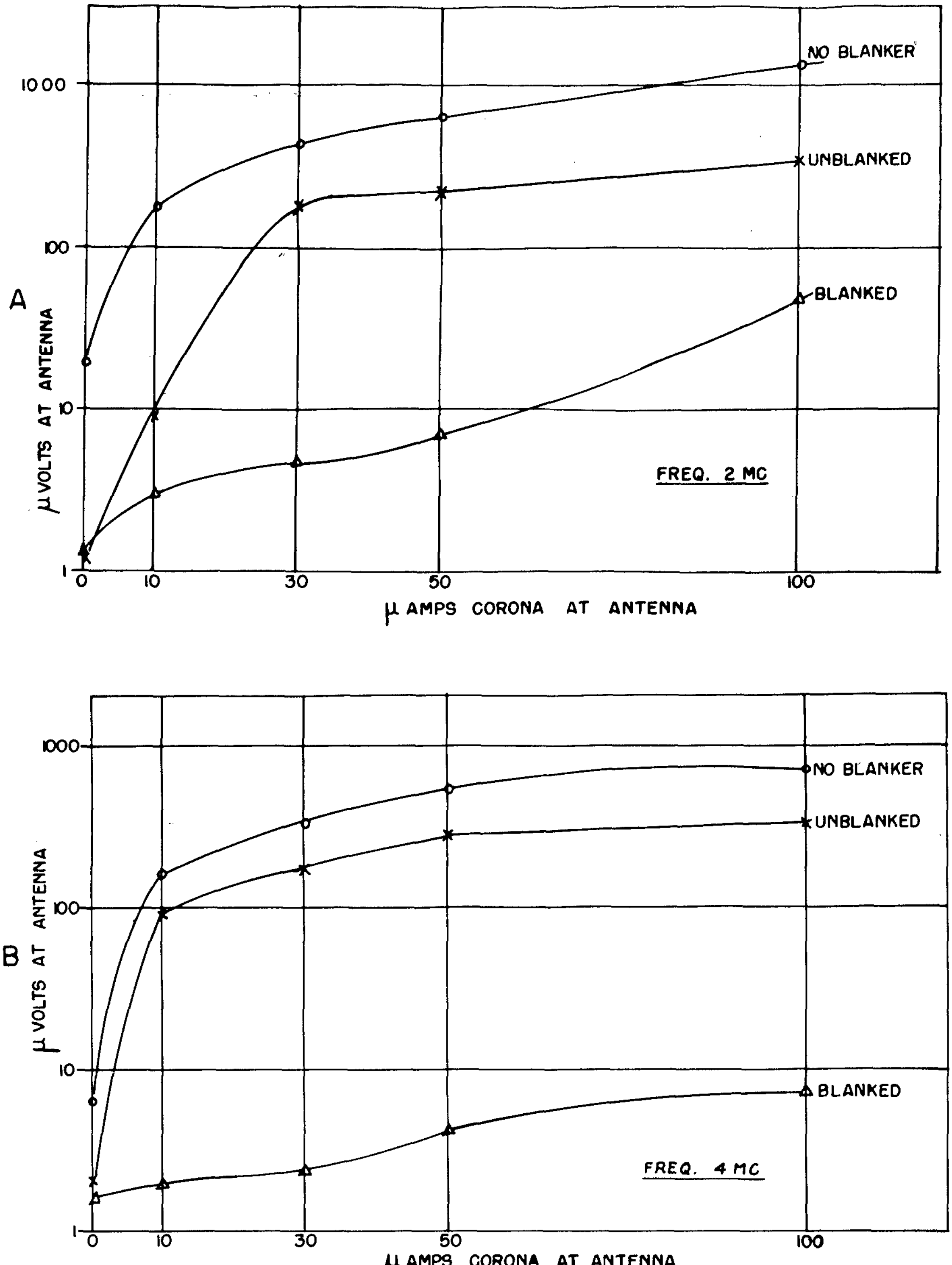
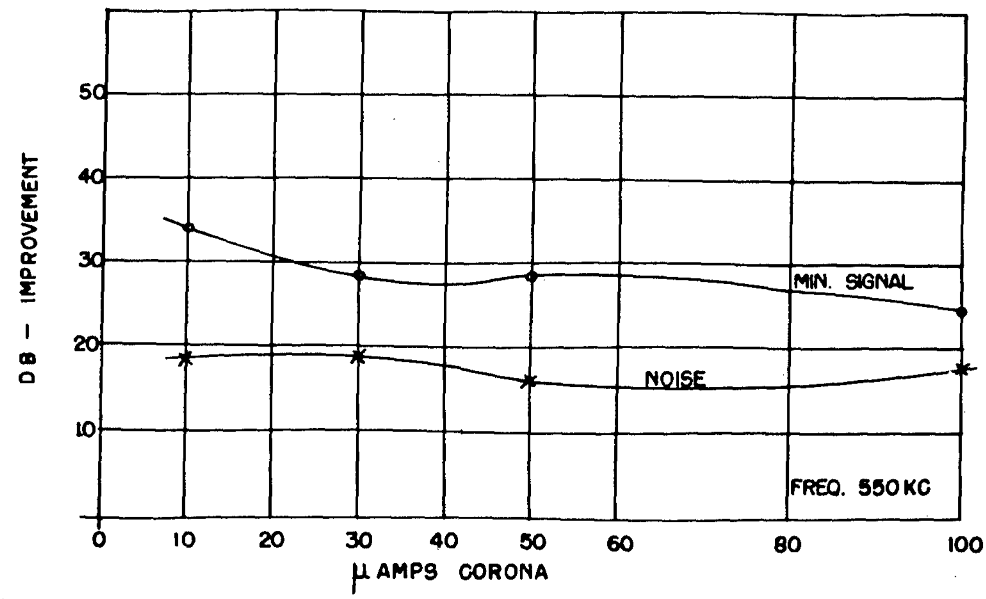


FIG. 4 MIN. RF SIGNAL - VS - CORONA CURRENT

B



A

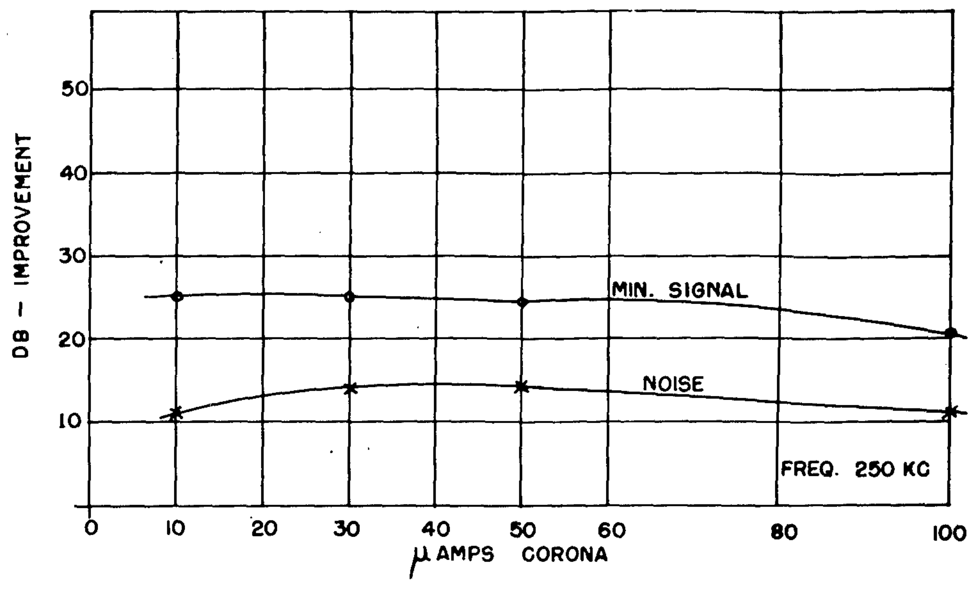


FIG. 5 DB - IMPROVEMENT RATIO VS CORONA CURRENT

A

B

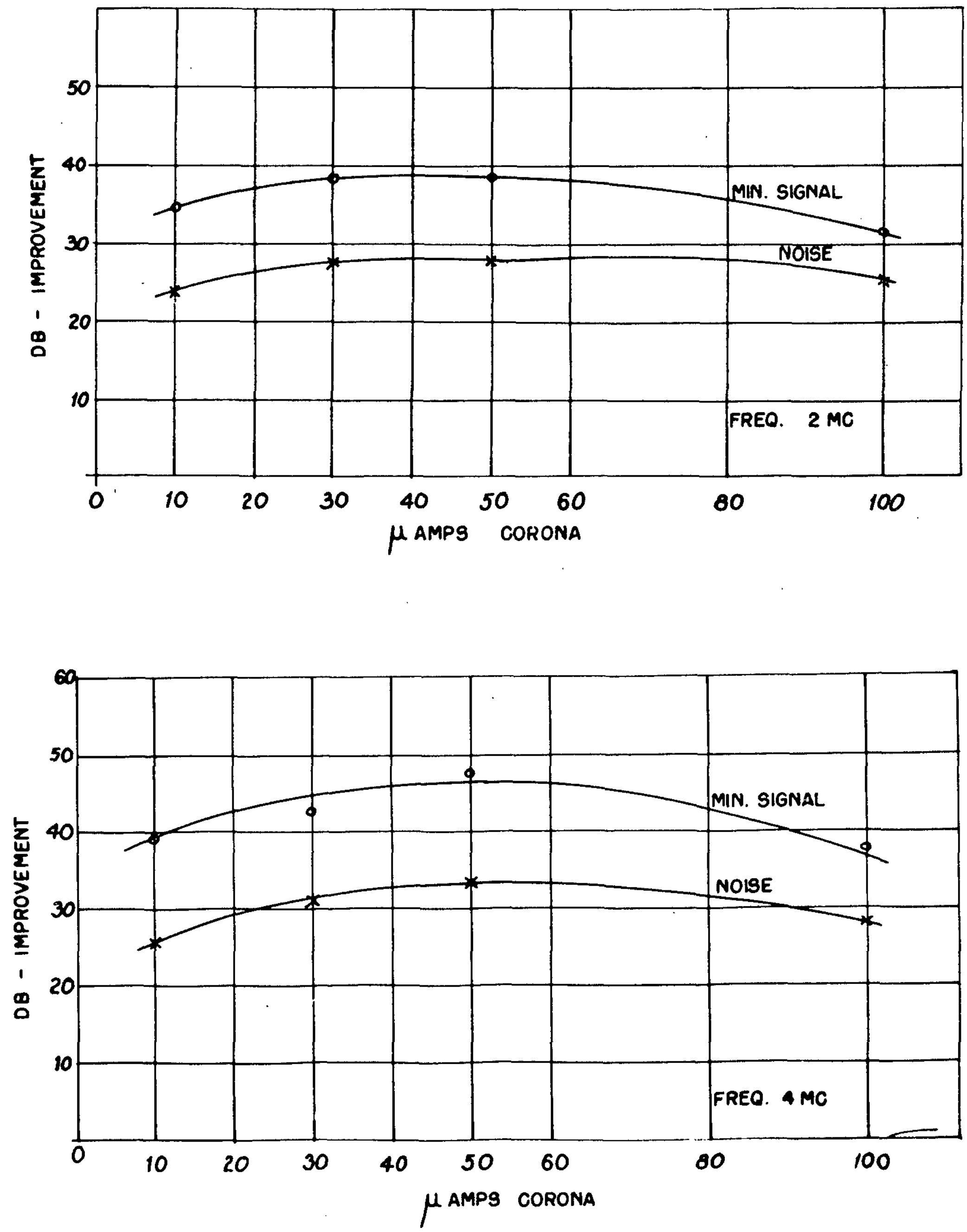


FIG. 6 DB IMPROVEMENT RATIO VS CORONA CURRENT

found that the 50 microvolt signal could be read solidly through 50 microamperes of corona current. At 70 microamperes, voice reception was poor. However, a more continuous signal such as music, could be understood through corona currents up to about 110 microamperes. With the blanker out of the circuit, the signal becomes unreadable immediately as the antenna goes into corona.

c. Stoddard NM 10A: The performance of the blanker at low frequencies was determined by making use of a low frequency receiver (Stoddard NM 10A). The test procedure used was similar to the medium and high frequency tests. The curve of Figure 7 shows the minimum usable signal vs frequency and Figure 8 shows the noise improvement due to the use of the blanker at 50 microamperes of corona current. The minimum usable signal is higher and the noise improvement is lower at the low frequencies. This is due to several things, one of which is the fact that low frequency tuned circuits will ring for a much longer period of time. It may be stated very generally that:

$$t = K \frac{1}{f_r 2}$$

where t = duration of ringing.
f_r = resonant frequency of the tuned circuit.
K = proportionality constant

Since the blanker is not ideal as yet, a few corona pulses do reach the receiver and cause the tuned circuits to ring. Also, the blanking residuals, which are small pulses, cause more noise at the low frequencies than at the medium of high frequencies as evidenced by the fact that above 550kc the noise due to blanking residuals measured less than 10 microvolts. At the low frequencies they measured as high at 35 microvolts for the same corona current. This, in itself, can cause considerable trouble in very sensitive receivers such as the Navaglobe receiver which was tried only briefly with the blanker.

Development of the Beam Deflection Switching Tube, described in WADC Technical Report No. 52-65, should alleviate this problem. It may be noted that the increased noise at these lower frequencies is compensated for, in part, by the fact that stronger signals are generally available in this portion of the spectrum.

Some difficulties are expected, when the blanker is flight tested, because of the straight-through or cascaded amplification, and of the very non-linear amplification designed into the pulse channel. Anticipating this, a simple RC filter was incorporated, designed to attenuate broadcast frequencies and those below, since such frequencies are liable to cause the most trouble. Other changes in the pulse channel are contemplated to further improve its operation.

There is also Signal Channel cross-modulation present. The use of an RC high pass filter is being considered in the present models in order to reduce interference of the broadcst signals and the resulting beats.

A general modification of the signal channel is also being considered in that the reduction of losses in the coincidence stages will reduce requirements

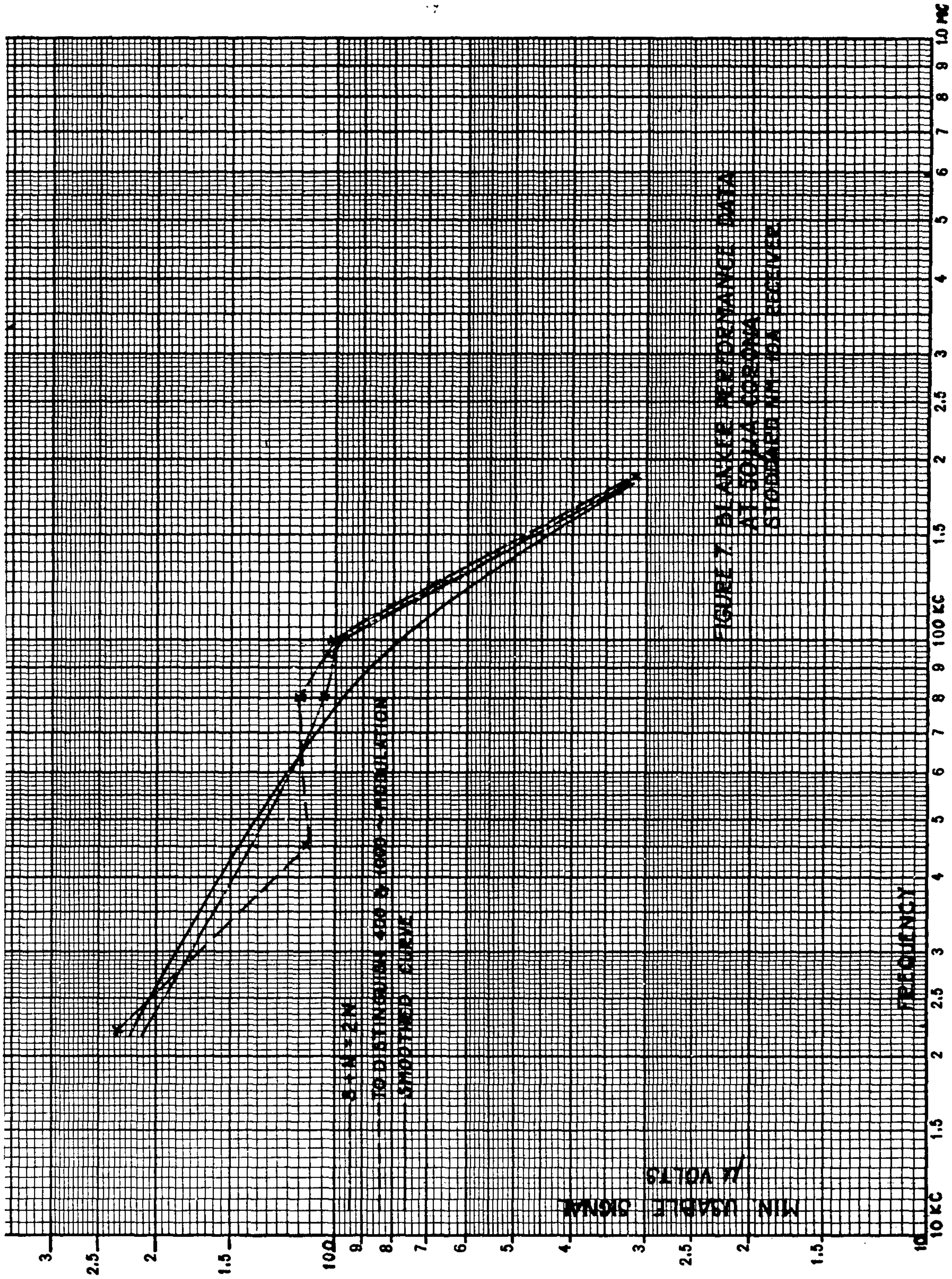


FIGURE 7 BLANKER PERFORMANCE DATA
STODDARD NM-10A RECEIVER
S + N = 2N
SMOOTHED CURVE
FREQUENCY
MIN USABLE SIGNAL
µ VOLTS

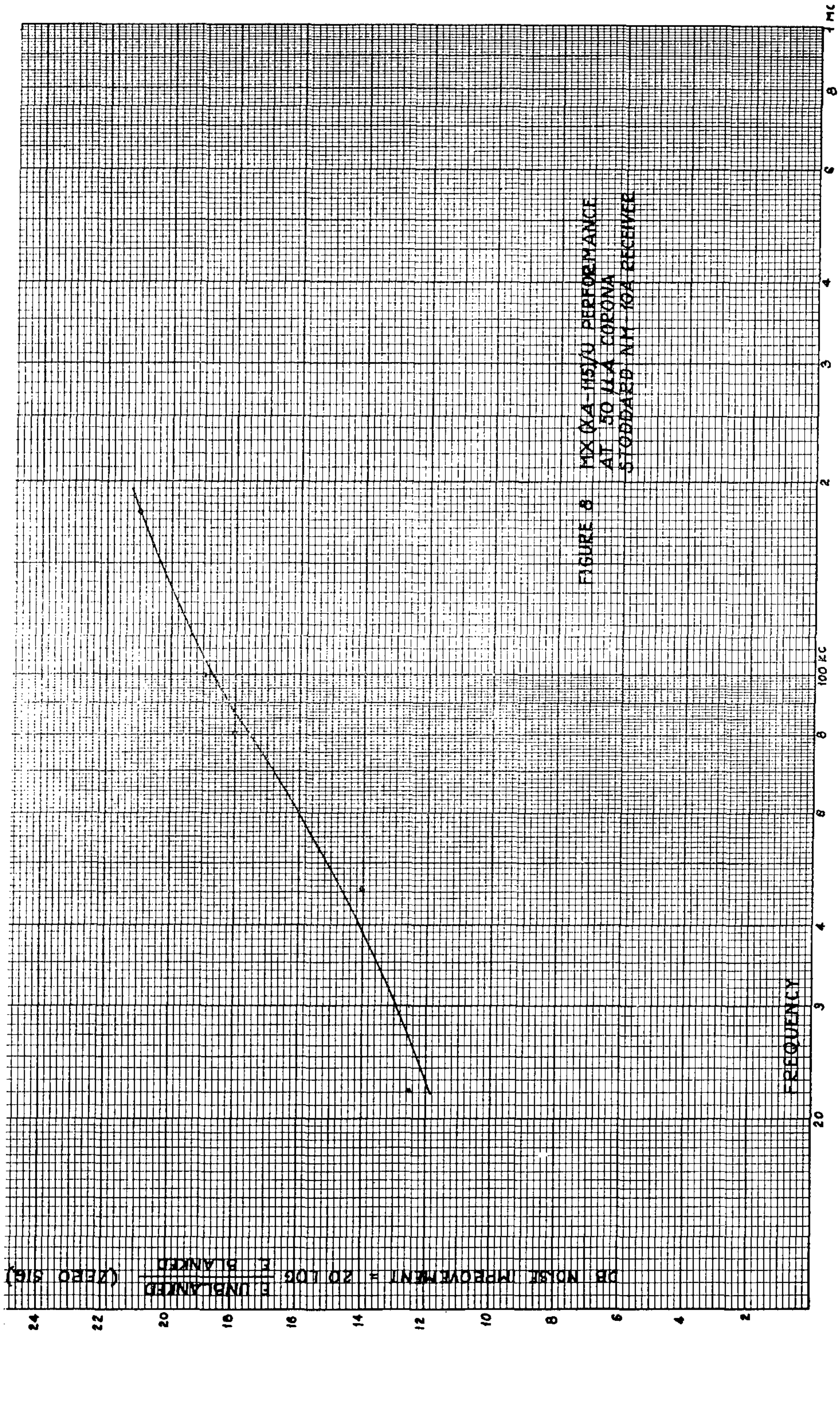


FIGURE 8 MX (XA-115)/U PERFORMANCE
AT 50 µA CORONA
STODDARD NM 10A RECEIVER
FREQUENCY
100 KC
1 MC
DB NOISE IMPROVEMENT = 20 LOG E UNBLANKED / E BLANKED (ZERO SIG)

of great gain now present in the video stages of the Signal Channel. Thus, the reduced gain which is realized in the video stages will dictate reduction in signal channel cross-modulation.

Loran Receivers

Radar Set AN/APN-9 was tested with the Interference Blanker, as shown in Figure 9. Loran signals from Test Set TS-34(XA)/UP were applied to the transmitting antenna, as shown. Because of the inflexibility of the test set, a wide range of data points could not be taken.

With the corona set at threshold level (1 to 2 microamperes) a signal of 25 microvolts could barely be read when the antenna was applied directly to the Loran receiver. When the blanker was inserted between the antenna and the receiver, a 7 microvolt signal could be read with ease through the threshold corona current.

The test set was then adjusted to give about a 23 microvolt signal at the input to the blanker. This signal could be read through about 50 microamperes of corona current.

Radar Set AN/APN-70 was also tested under similar conditions and with the same test set-up used above. Again, 50 microamperes of corona current were about the maximum value that could be tolerated with about 23 microvolts of signal at a standard Loran frequency of 1950kc. 60 microamperes could be tolerated if the signal were increased to about 28 microvolts. The photographs in Figures 10 and 11 show the effects of corona interference on the AN/APN-70 both with and without the blanker in the antenna circuit. Figures 12 and 13 graphically illustrate the effect of increasing corona current on the Blanker-Loran system for a given signal.

Operation of the AN/APN-70 at low frequencies (100kc) with the blanker shows results comparable to the results obtained with the Stoddard NM 10A Low Frequency Receiver. A 320 microvolt signal could be read through about 30 microamperes of corona current with some difficulty. Increasing the signal strength to 390 microvolts gave a very definite reading.

Again, the fact that more signal is required to overcome a given value of corona current at low frequencies is compensated for, in part, by the larger signal strengths generally available in this spectrum.

As an indication of what value an Interference Blanker might have, it was reported that on the "Musk Calf Project" flights of 24 and 25 April 1946, the corona current never exceeded 50 microamperes and yet Loran reception was lost for about 5 hours due to precipitation static interference. On another series of 10 flights on the project between 1 April 1947 and 31 May 1947, it was estimated by U. S. Naval Observers that 17.3% of the total flight time was subject to precipitation static. Reception of Loran signals was completely blocked during this time.

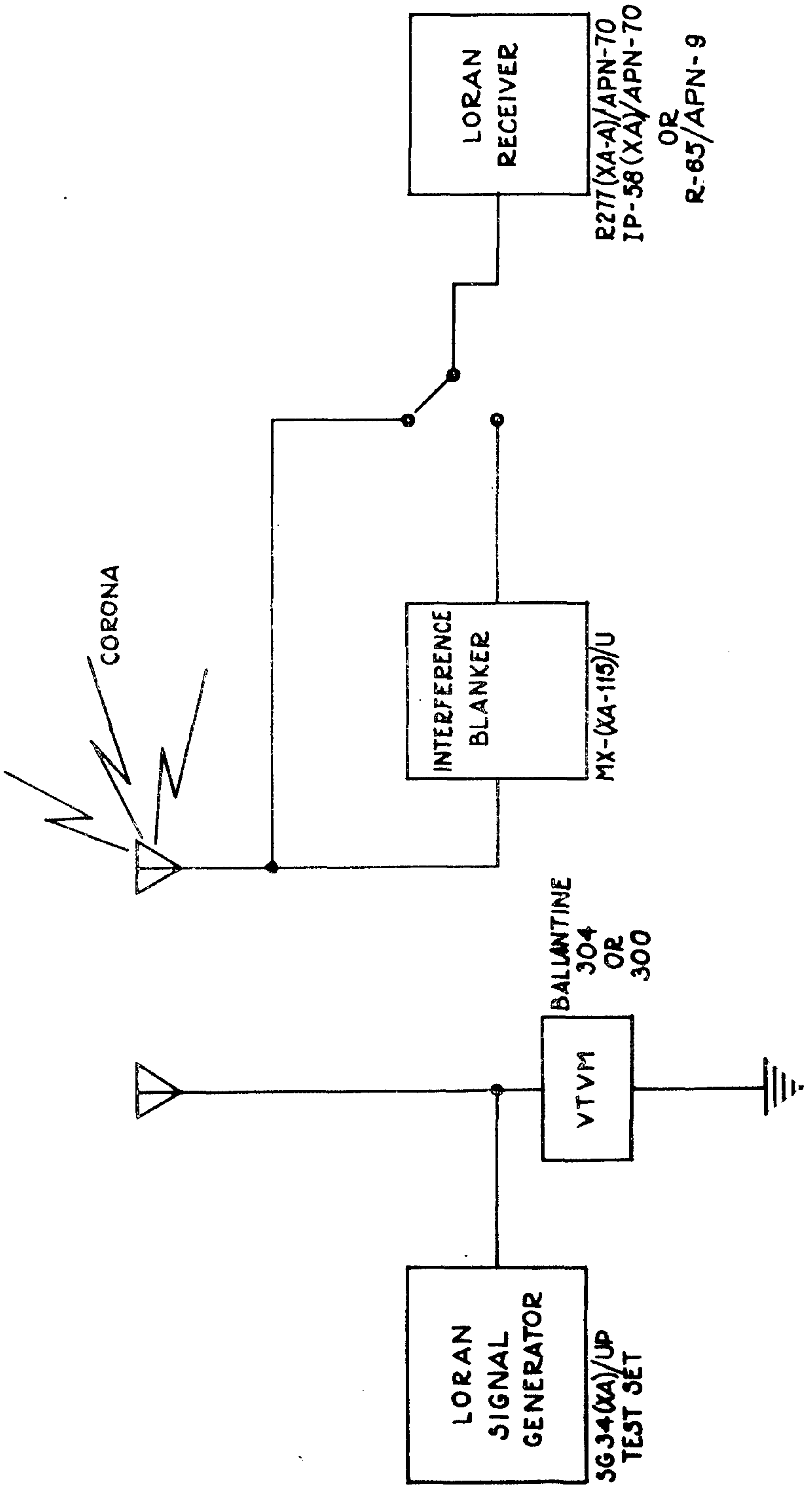
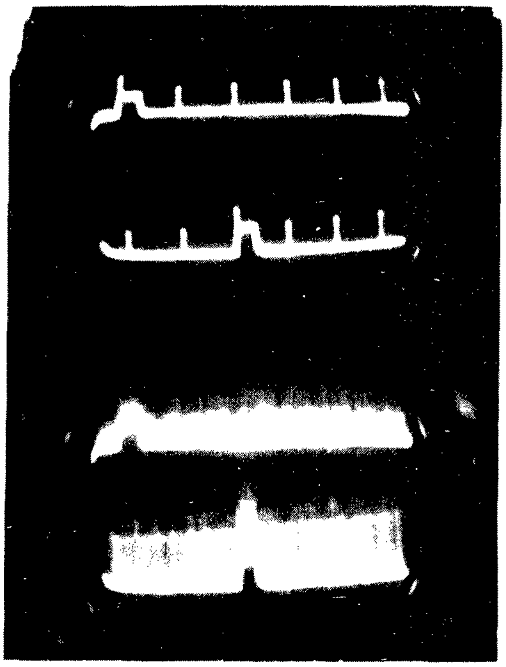


FIGURE 9. SET UP FOR TESTING INTERFERENCE BLANKER WITH LORAN EQUIPMENTS.

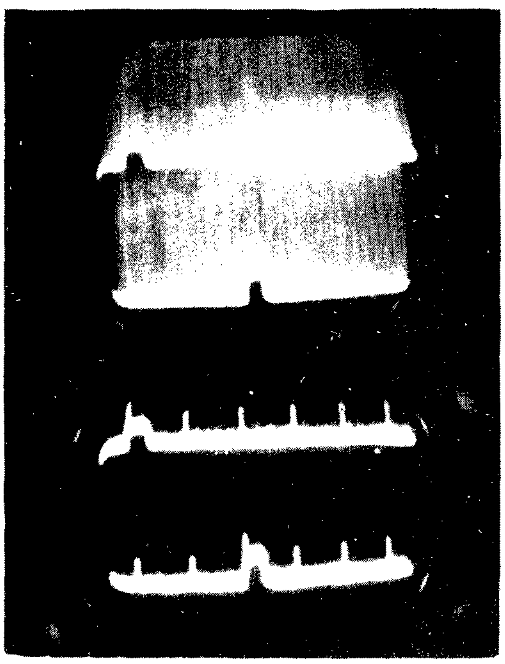


40 MICROVOLT SIGNAL - Freq. 1.95 MC
No Corona Current

40 MICROVOLT SIGNAL - Freq. 1.95 MC
Threshold Corona Current

Figure 10

AN/APN-70 Loran Presentation
No Blanker in Use

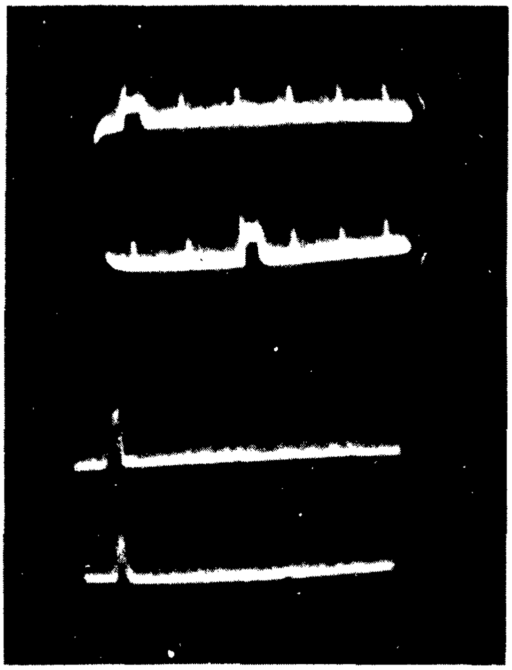


40 MICROVOLT SIGNAL - Freq. 1.95 MC
25 Microamps Corona Current
Not Blanked

40 MICROVOLT SIGNAL - Freq. 1.95 MC
25 Microamps Corona Current
Blanked

Figure 11

AN/APN-70 Loran Presentation
With MX-(XA-115)/U Interference Blanker



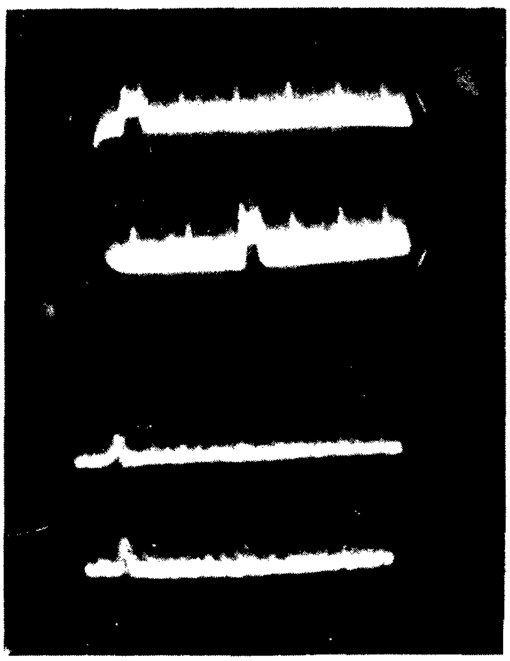
Function 1

40 MICROVOLT SIGNAL - Freq. 1.95 MC
50 Microamps Corona Current
Blanked Condition

Function 2

Figure 12

AN/APN-70 Loran Presentation With Interference Blanker



Function 1

40 MICROVOLT SIGNAL - Freq. 1.95 MC
80 Microamps Corona Current
Blanked Condition

Function 2

Figure 13

AN/APN-70 Presentation With Interference Blanker

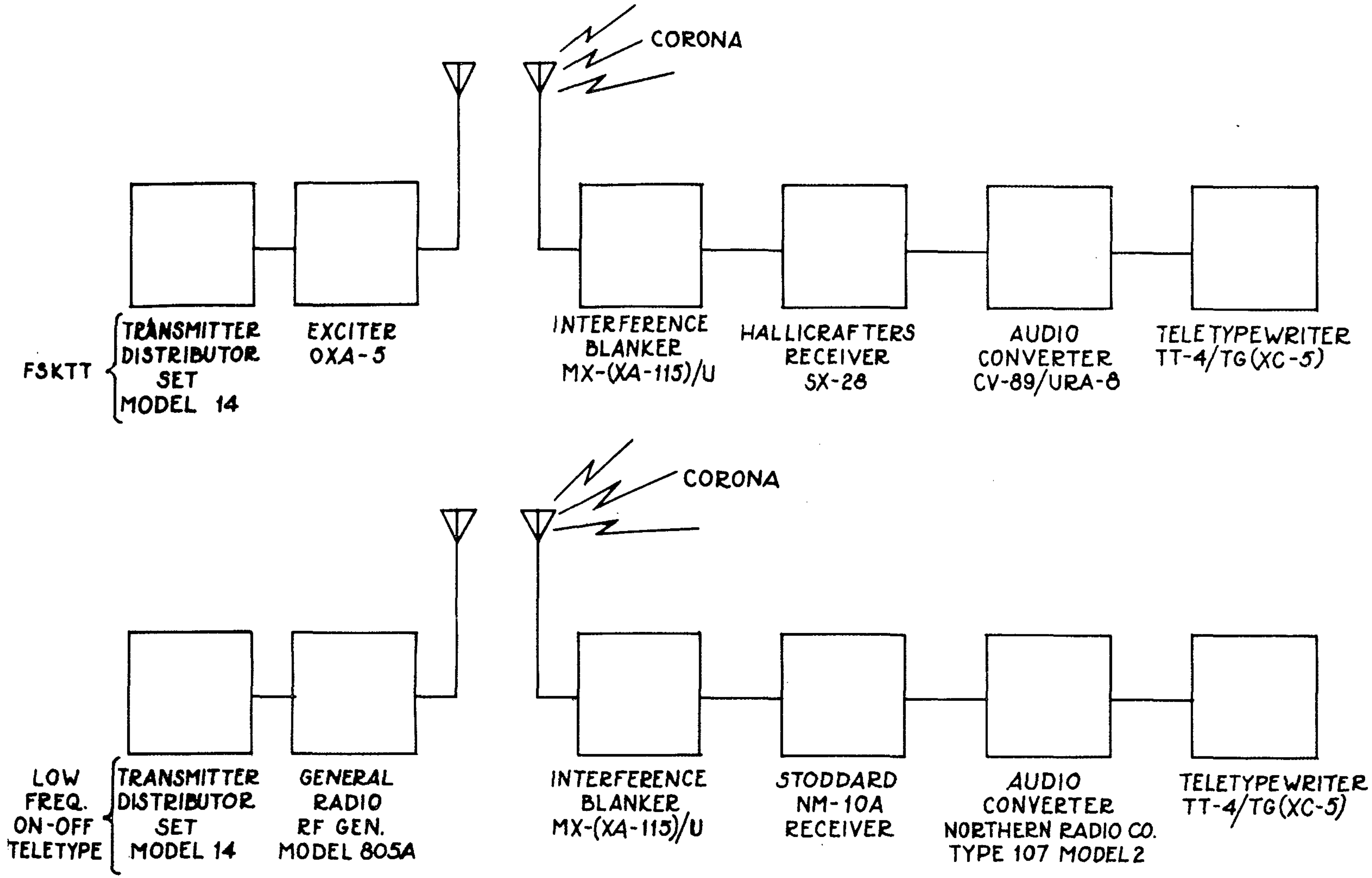


FIGURE 14. SET UP FOR TESTING INTERFERENCE BLANKER WITH TELETYPE EQUIPMENTS.

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EDJ  NNHITD
        INKMIDXQACYFo;.$2α
                    !2 N
DWD                      DH BAP-
J  FAE NL
  NIOEST TCANS
AWJJVKYPBY
JDI
    DLBQJAN DTTFE
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     GWVR ERNUDGV
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             I
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Figure 15

FSK Teletype Presentation
Frequency 2.62 MC - Antenna Goes Into Corona
At the Word "Deemed". Blanker not in Use.
40 Microvolt Signal

It was noted in the laboratory tests that the Loran Antenna Couplers CU-167/APN-9A and CU-34(XA)/UP, if used after the Interference Blanker, made little or no difference in the operation of the blanker with respect to the Loran receivers. This makes it possible to use a single blanker with more than one equipment.

Teletype Communications

The "FSK" and "On-Off" teletype test set-up are shown in Figure 14.

FSK teletype test set-up consists of the Converter CU-89/URA-8 and Teletypewriter TT-4/TG-(XC-5) with Radio Receiver Model SX-28 at a frequency of 2.62mc. A Transmitter Distributer Set Model 14 and Exciter OXA-5 are used to produce the necessary signal.

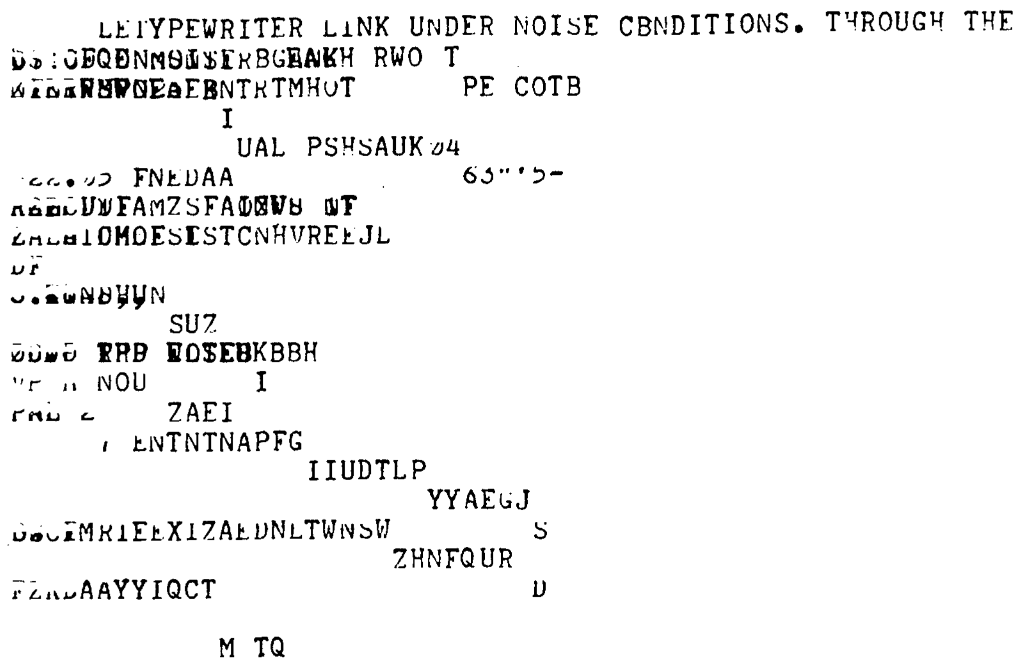

Figure 16

FSK Teletype Presentation
Frequency 2.62 MC - Blanker Not Operating
40 Microvolt Signal - 110 Microamps Corona Current

Results of FSK teletype reception at a fixed minimum RF signal of 40 microvolts at the receiving antenna and at various corona currents, with and without the Interference Blanker in use, are shown in Figures 15, 16, and 17.

Figure 15 shows the great amount of degradation in teletype reception with no blanker in the circuit and at threshold corona. A signal of approximately 300 microvolts was required for the system to print without errors under the above conditions.

Figures 16 and 17 clearly depict the results of "No Blanker" and "Blanker" operations of FSK Teletype equipment at a received signal of 40 microvolts (minimum readable) and at 110 microamperes corona current, which is equivalent to approximately 700 microvolts of noise.

The FSK teletype, as expected, outperformed the other equipment considered within this report.

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TESTING A TELETYPEWRITER LINK UNDER NOISE CONDITIONS. THROUGH THE
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IN NOISE CONDITIONS HERETOFORE DEEMED IMPOSSI/3. THIS IS A TEST TRANS
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Figure 17

FSK Teletype Presentation
Frequency 2.62 MC - Blanker in Operation at Receiving Antenna
40 Microvolt Signal and 110 Microamps Corona Current

A very low frequency (CW or On-Off) teletype was tried at a frequency of 25kc. The test set-up used in shown in Figure 14. A tape keyer (Transmitter Distributer Set Model 14) and General Radio Model 805-A Signal Generator were the signal source. The receiver set-up was the Interference Blanker, Stoddard NM 10A Noise Meter, the Audio Converter (Northern Radio Co. Type 107, Model 2), and the Teletypewriter TT-4/TG-(XC-5).

Figures 18 and 19 depict examples of on-off teletype reception at a frequency of 25kc and a minimum readable signal at the receiving antenna of 250 to 300 microvolts. With no corona, reception was fair. The message was completely unintelligible at four microamperes corona without the blanker. With the blanker in operation, the signal was completely readable. However, errors were more frequent than without corona. At a corona current of 30 microamperes a limit was reached where even with the blanker in operation reception was unreadable. However, a signal to noise improvement was realized to some extent.

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NOW IS THE TIME FOR ALL GOOD MEN TO COME TO THE AID OF THEIR PARTY

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NOW IS THE TIME NOR ALL GOOD MEN TO COME TO THE AID OF THEID PARTY

Figure 18 a - b

On-Off Teletype Presentation
Frequency - 25 KC - Blanker in Operation
a. No Corona Current
b. 4 Microamps Corona Current

An advantage of the FSK teletypewriter is the better signal to noise ratio. In the opinion of the teletype personnel:

FSK teletype requires a 2/1 signal to noise ratio.
On-Off teletype requires an 8/1 signal to noise ratio.
Voice requires a 4/1 signal to noise ratio.

Thus, the FSK teletypewriter, not too easily affected by noise, shows the best signal improvement when the blanker is used in precipitation static, while the

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Figure 19 a - b

On-Off Teletype Presentation
Frequency - 25 KC - Blanker in Operation
a. 30 Microamps Corona Current
b. 45 Microamps Corona Current

on-off teletypewriter, which is very susceptible to noise pulses occurring during the spaces between the on or pulse conditions, shows a very poor signal improvement ratio. Even under ideal conditions, the on-off teletype is effected by circuit and manmade noises of low amplitude. The teletypewriter personnel are very dissatisfied on the operation of the on-off teletypewriter equipment because of its great susceptibility to noise impulses. However, the FSK teletypewriter showed such promise for successful operation with precipitation static present that the teletypewriter personnel are ready to aid the flight tests of the Interference Blanker.

Radio Compass

Initial tests have been made with the Interference Blanker MX-(XA-115)/U connected into the sense antenna channel of the AN/ARN-6 Radio Compass. A bearing shift of about 180 degrees for a 1410kc signal was observed due to blanker delay. Sense antenna corona up to 200 microamperes did not interfere with the ADF function (loop antenna was outside the interference area), although the signal became unintelligible.

Protection of the sense antenna circuits alone against corona by the blanker is not sufficient. However, the performance is sufficiently promising to recommend further study of the use of the blanker in the loop and sense antenna circuits to realize interference reduction in precipitation static and 'sferics.

SECTION III

CONCLUSIONS

It is concluded:

That the beam deflection switching tube (described in WADC Technical Report No. 52-65) should be developed in order to further reduce the amplitude of switching transients so that the blanker may be used more effectively with receivers of high sensitivity.

That steps be taken to remove or reduce cross-modulation effects from the pulse channel and signal channel.

That, according to laboratory tests, and should flight tests prove the blanker satisfactory, even the present model of the blanker would offer sufficient improvements to reception to merit consideration as an interim equipment.

SECTION IV

RECOMMENDATIONS

Recommendations are as stated under "CONCLUSIONS." In addition, should flight evaluation tests yield approval of the system, it is recommended that the design be used as a sample of circuitry for an Air Force Procurement Contract of Interim Equipment.

It is recommended that extensive flight test data on characteristics of signals and interference limits, as well as flight test oscillograms of precipitation static and 'sferic interference pulses be obtained. Flight tests should include operation of the combination equipments under 'sferic conditions.

It is recommended that research and development continue on Interference Blanker Circuitry so that future models may incorporate modifications of circuitry already under consideration, and such further features as blanker protection against transmitter, radar and other signals propagated from the same aircraft, some form of automatic balancing control, coincidence circuitry designed around the beam deflection switching tube, and others as may be developed.

Cross-modulation difficulties in both the Signal and the Pulse Channels may be expected under flight conditions, and it is recommended that special effort be directed toward obtaining all possible quantitative data regarding this subject.

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